



**Public Workshop on Draft Proposal to Reduce Emissions from Ship Auxiliary Engines**

**Discussion of Draft Proposal**

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May 18, 2005



 California Environmental Protection Agency  
AIR RESOURCES BOARD

## Summary of Draft Proposal

- Requires use of low sulfur MGO/MDO in oceangoing ship auxiliary engines
- Applies to ships at dockside or in California Coastal Waters
- Includes generators in diesel electric vessels, but excludes other propulsion engines, and turbines

## California Coastal Waters



## Removed Frequent Visitor Provisions

- Removed requirements specific to vessels that stopped at CA ports 5 or more times annually
  - Provisions require more time to craft than clean fuel provisions
  - Will develop separately for Board consideration in 2006

## Cleaner Fuels Provisions

- Revised implementation dates
  - 0.2% sulfur distillate on July 1, 2006
  - 0.1% sulfur distillate on Jan 1, 2010
- Allows use of marine diesel oil (MDO) meeting sulfur limits
- Vessel owners can apply for extensions

## Provision for Vessels Requiring Modifications

- For vessels requiring significant modifications to comply with rule
- Vessel owners can apply for up to a six month extension to 7/1/06 fuel limits
- Application must include:
  - detailed description of modifications necessary to comply with the rule
  - estimated cost and time to complete

## Record-keeping, Reporting, and Monitoring

- Report time/date/location during start and finish of fuel switching operations & entrance/exit in CCW
- Report types and % sulfur of fuels used in auxiliary engines in CCW
- Report types, amounts, and % sulfur of fuel purchases

## Record-keeping, Reporting, and Monitoring (Cont'd)

- Provide record-keeping specified in rule to ARB upon request
- Provide access to vessel for inspection of records, or collection of fuel samples for testing

## Alternative Compliance Plan (ACP) Revisions

- Averaging under the ACP limited to auxiliary engines
  - Cannot count main engine reductions toward compliance with auxiliary engine rule
  - Addresses concerns about reduced emission reductions at dockside

## Definitions and Test Methods

- New definitions added
  - ASTM, ISO, Innocent passage, marine diesel oil, roadstead
- Test methods to be included on finalization of ISO 8217



**Public Workshop on Draft Proposal to Reduce  
Emissions from Ship Auxiliary Engines  
PM Emissions and Fuel  
Sulfur Content**

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## PM Emissions versus Sulfur Content

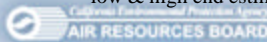
- Sulfur in fuel is converted to SO<sub>x</sub>, and to a lesser extent, sulfate (PM)
- Estimates of sulfate PM formed from the fuel sulfur vary based on the % conversion of sulfur to sulfate (~2-5%)
- We estimate that each 0.1% sulfur increase, raises sulfate PM by 0.03-0.06 g/kw-hr (with a 2-4% conversion rate)



## Sulfate Emissions (g/kw-hr) versus % Fuel Sulfur

Fuel Sulfur (% by wt.)	Sulfate (low-end)	Sulfate (high-end)
0.1	0.03	0.06
0.2	0.06	0.12
0.5	0.15	0.30
1.0	0.3	0.6
2.7	0.8	1.6

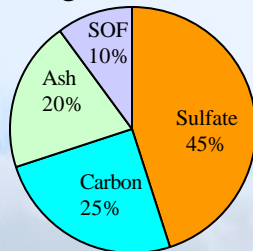
\* low & high end estimates using 2% & 4% sulfur to sulfate conversion rates, respectively



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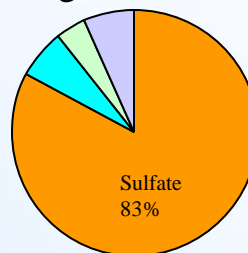
## Differing Estimates of Diesel PM for Marine Engines Using Residual Fuel

USEPA  
1.7 g PM/kW-hr



Source: Environ International Corp.,  
"Commercial Marine Emission Inventory  
Development," 2002 and USEPA NPRM  
for Category 3 Engine Rule, 2002

Container Ship In-use Testing  
1.8 g PM/kW-hr



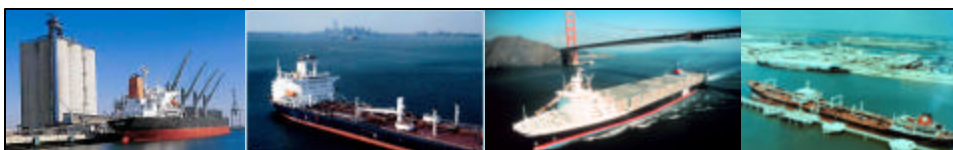
Source: Sine Maersk Test Report:  
estimate for auxiliary engine at  
73% load



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## Estimated PM Emission Reductions from Fuel Change

- USEPA and Entec Report emission factors estimate 63% PM reduction
- Other data indicates reduction on the order of 80%
- Testing on container ship auxiliary engine using residual and distillate fuels forthcoming



### Public Workshop on Draft Proposal to Reduce Emissions from Ship Auxiliary Engines **Ship Retrofit Costs**

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**May 18, 2005**



## Potential Ship Modifications and Estimated Costs

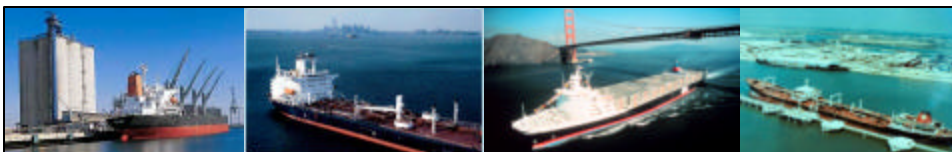
- Ship survey identified vessels requiring retrofits (20% of vessels)
- Potential modifications reported
  - Adding tanks and piping, mixing tanks, fuel coolers, purifiers
  - Modifications to fuel pumps, injectors, nozzles, lubrication systems
  - Class society approvals & inspections

## Estimated Costs of Modifications

- USEPA - \$50,000
- Follow-up with companies to estimate cost of modifications
- One respondent - \$350-500,000
- Key factors: type of modifications required, country where work performed, dry dock dates

## Proposal to Accommodate Vessel Modifications

- Provision allows operators to apply for an extension of up to six months if significant vessel changes required
- Applications must include detailed descriptions of the modifications necessary and estimated costs



### Public Workshop on Draft Proposal to Reduce Emissions from Ship Auxiliary Engines **Survey Results**

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**May 18, 2005**

## Survey Summary

- Ship survey mail out in Dec. 2004
- Due date February 28, 2005
- Survey information necessary
  - Develop ship auxiliary engine rule
  - Update the ship emissions inventory
  - Feasibility study of shore-side power

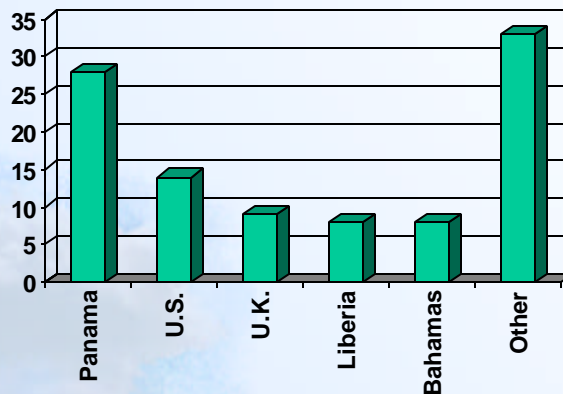
## Survey Summary

- 36 companies responded out of a total of 150 owner/operators and shipping agents (as of 4/12/05)
- 327 vessels reported (CSLC reported ~1900 vessels in 2004)
- Over 1,400 engines reported
- Still encourage submittals

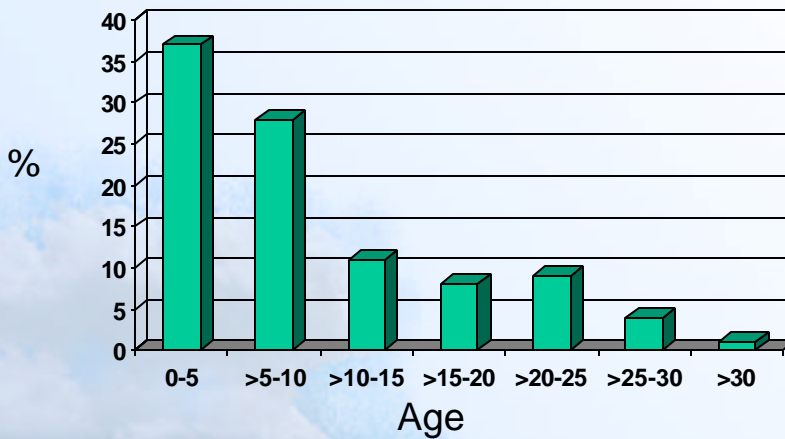
## Response Rate by Vessel Type

Vessel Type	No. of Ships	% by # Ships	CSLC % Visits	CSLC % # Ships
Container	180	55%	49%	31%
Auto	69	21%	8%	12%
Cruise	41	13%	7%	2%
Tanker	21	6%	19%	19%
Other	16	5%	17%	36%

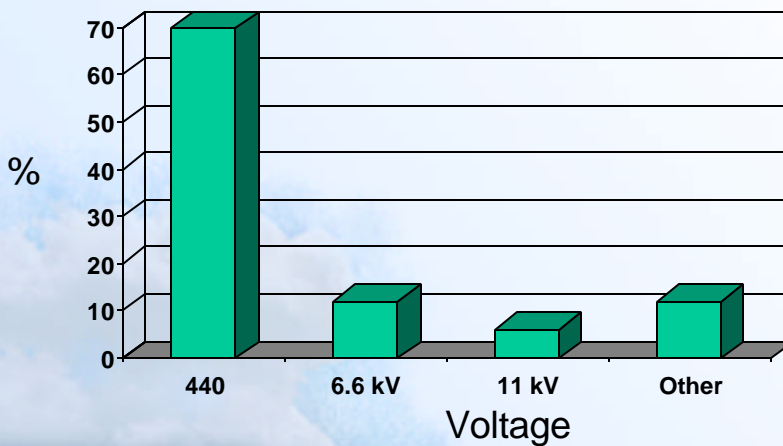
## Surveyed Ships by Flag



## Vessel Age Distribution



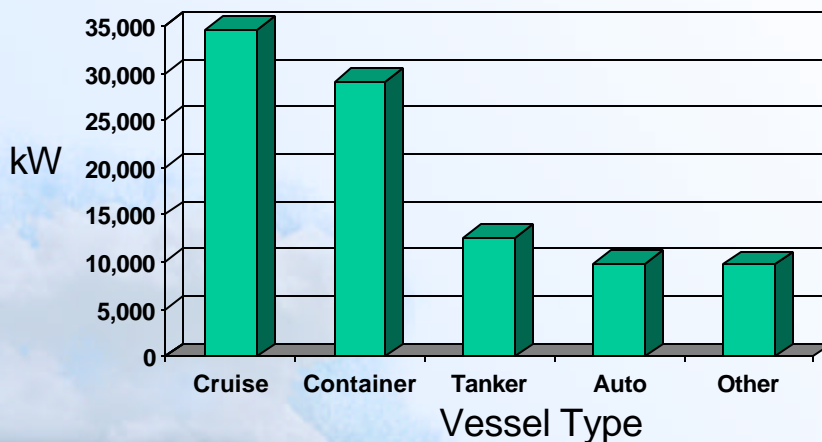
## Ship Electrical Power



## Main Engine Data

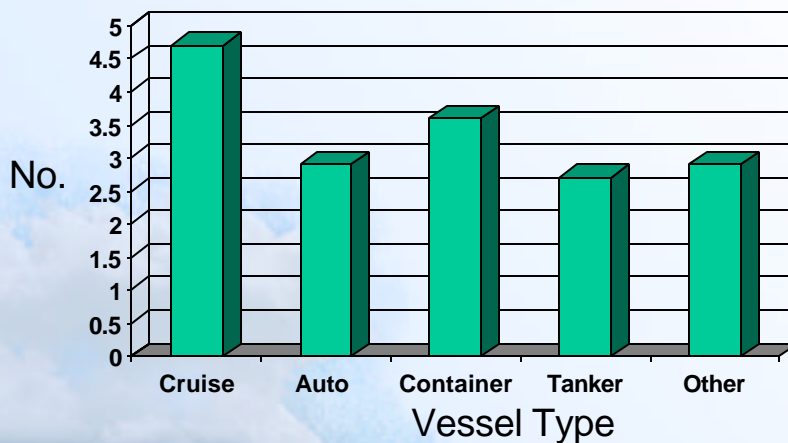
- 97% piston engine, 3% turbines
- 95% two-stroke, 5% four-stroke
- Mostly manufactured by MAN B&W and Sulzer/Wartsila
  - Other mfgs. may be under license from MAN B&W or Wartsila
- 99% use residual fuel

## Normal Cruise Power (kW)

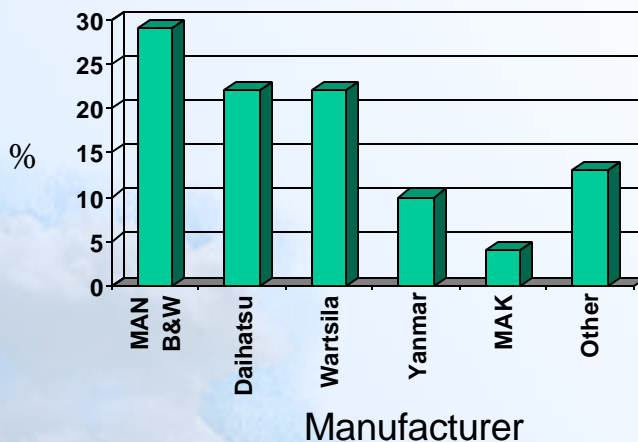




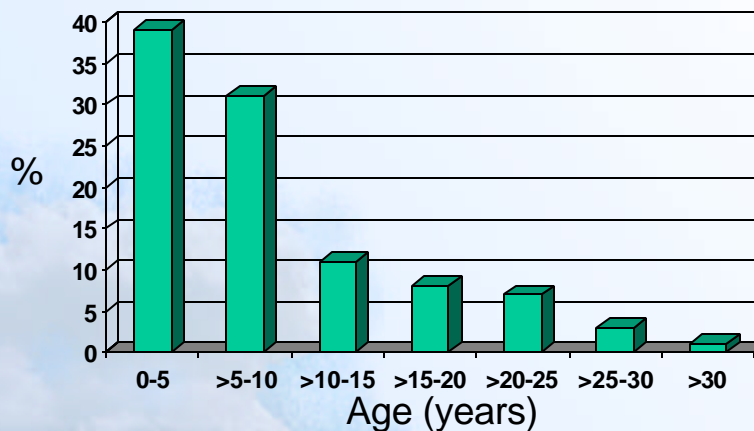
## Number of Auxiliary Engines



## Auxiliary Engines by Make



## Auxiliary Engine Age

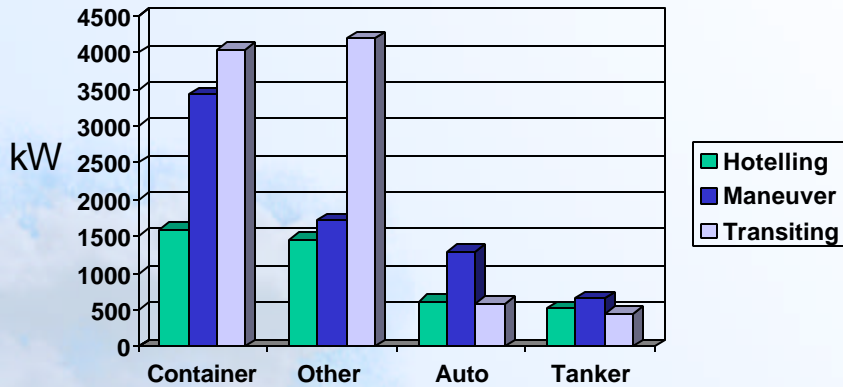


## Fuels Used in Auxiliary Engines

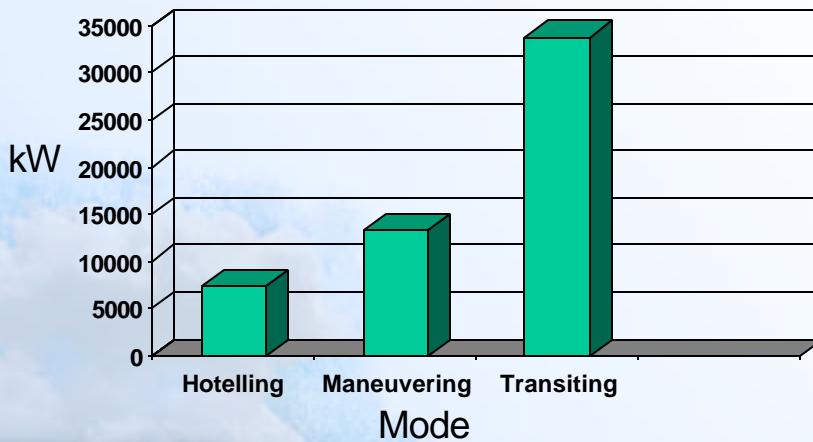
Fuel Type	No. of Engines	% of Total	% Sulfur in Fuel
Residual	881	78%	2.5%*
Distillate	249	22%	0.5%*

\* Excludes data reported at ISO maximum, and fuels used in turbine engines.

## Total Power Generated by Shipboard Auxiliary Engines



## Total Power Generated by Cruise Ship Engines



## Ship Visit Breakdown

